Contrast-to-tissue ratio improvement by transmitted optimized binary signal in ultrasound pulse inversion imaging

Sébastien Ménigot, Jean-Marc Girault

Contrast-to-Tissue Ratio Improvement by Transmitted Optimized Binary Signal in Ultrasound Pulse Inversion Imaging

Sébastien Ménigot[1,2,†] and Jean-Marc Girault[2,‡]

[1] IUT Ville d'Avray, université Paris Ouest Nanterre La Défense, Ville d'Avray, France
[2] UMR-S930 "Imaging and Brain", université François Rabelais de Tours, Inserm U930, Tours, France

[†] sebastien.menigot@univ-tours.fr, [‡] jean-marc.girault@univ-tours.fr

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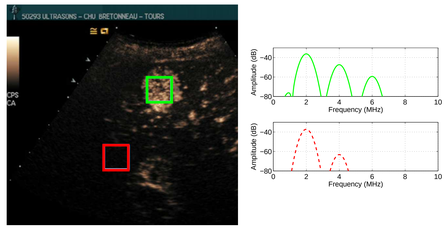
1. Introduction & Background

A. Ultrasound Contrast Imaging

- Injection of encapsulated microbubbles
- High nonlinear behaviour
- Contrast-to-Tissue Ratio

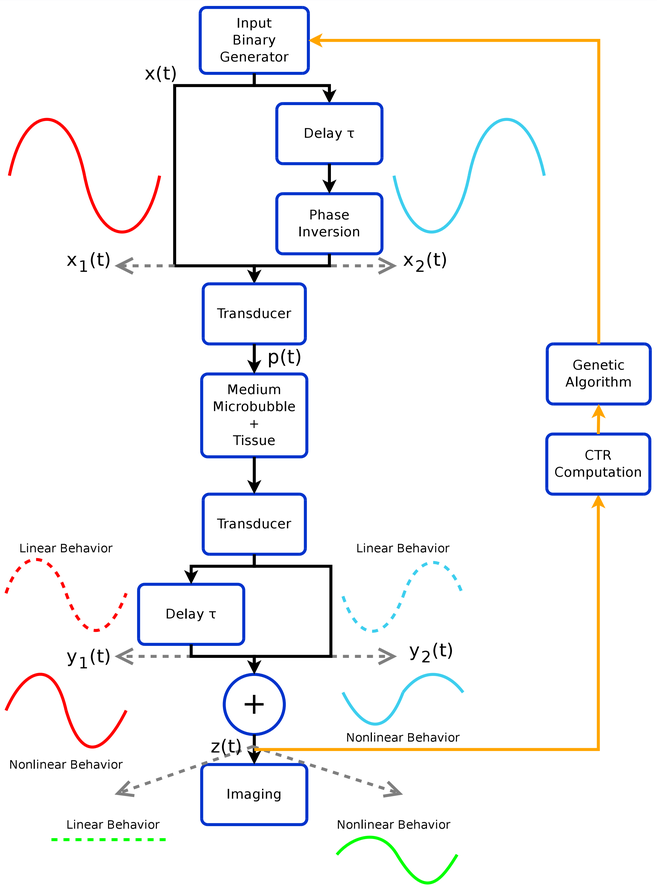
$$CTR = \frac{E_{microbubbles}}{E_{tissue}}$$



B. Simulation

- Marmottant model for a 2.5 μm microbubble
- Nonlinear propagation in tissue by Anderson's model
- Transducer: 4 MHz - 75%

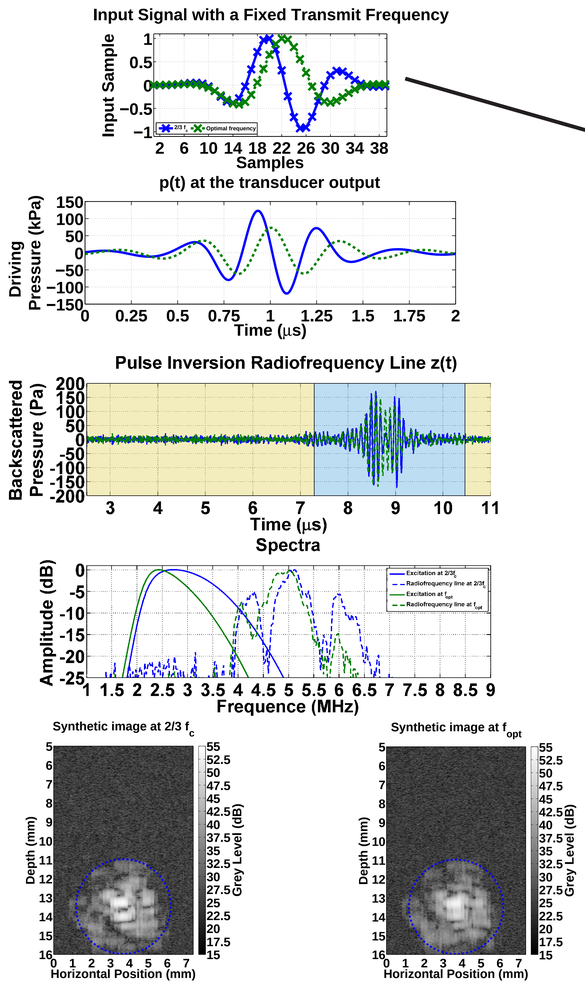
2. Pulse Inversion Ultrasound Imaging with Feedback



Increasing *CTR* by odd harmonic extraction

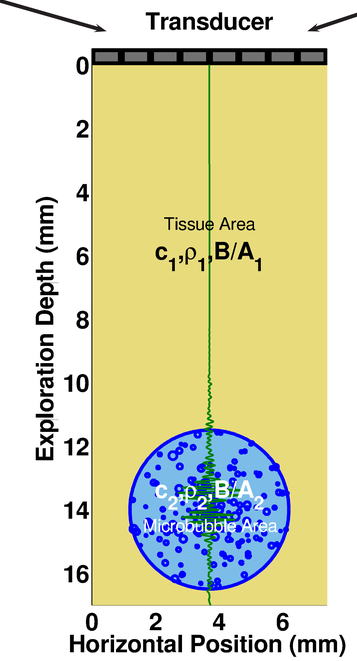
Simpson et al., IEEE T UFFC, 46(2), 1999

3. Usual Transmitted Pulse

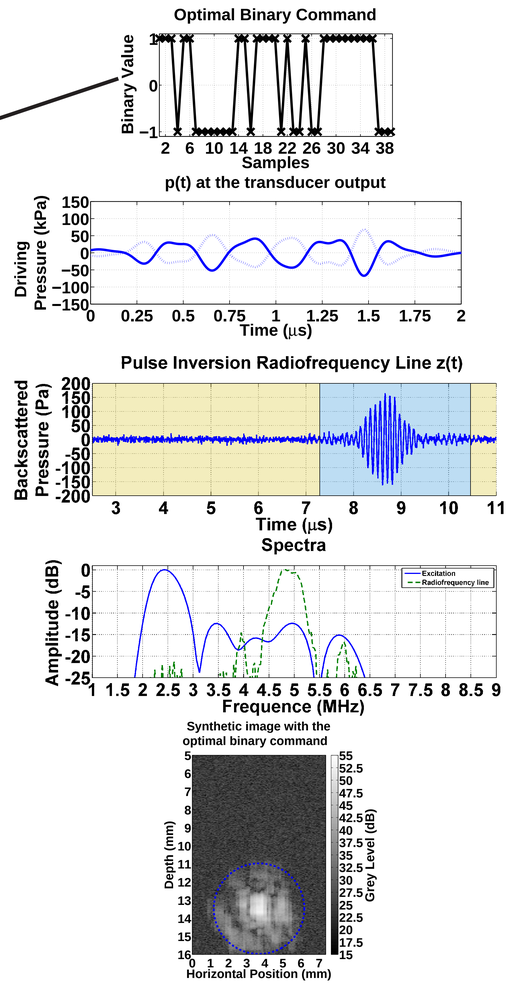


CTR = 13.6 dB

CTR = 16.8 dB

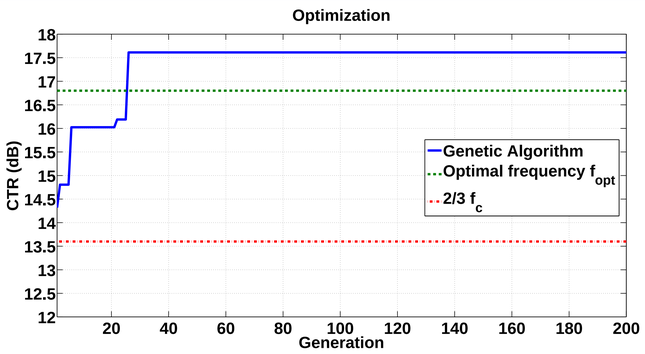


4. Optimal Binary Command



CTR = 17.6 dB

5. Optimization Process by Binary Genetic Algorithm



6. Discussion

- Automatic optimization of CTR
- Gain
  - 4 dB in comparison with an excitation at $2/3f_c$
  - 0.8 dB in comparison with an excitation at the optimal frequency

  Ménigot et al., Optimization of Contrast to Tissue Ratio by Frequency Adaptation in Pulse Inversion Imaging, IEEE T UFFC, 59(11), 2012
- Stochastic excitation combined with genetic algorithm $\rightarrow$ Nonlinear
- Nonlinear backscattered components only due to medium nonlinearities
- Prospects
  - Implementation on ultrasound scanner
  - Using programmable analogue transmitter